Journal of Global Change Data & Discovery. 2022, 6(3): 395-401
www.geodoi.ac.cn

Global Change Research Data Publishing & Repository

A July–August Mean-Temperature Dataset Reconstructed based on the Maximum Latewood Density of Hailar Pine in the North Greater Khingan Mountains (1781–2013)

Li, M. Q.[1*] Lan, Y.[2]

1. Key Laboratory of Land Pattern and Simulation, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China;
2. Guangdong Meteorological Observatory, Guangdong, Guangzhou 510640, China

Abstract: Tree-ring cores (10 mm) of Hailar pine (*Pinus sylvestris* var. *mongolica*) were collected at the upper tree lines (51.79°N, 123.08°E, 950 m a.s.l.) from the Huzhong National Nature Reserve in the north Greater Khingan Mountains in September 2013. The maximum latewood density (MXD) was obtained using a DENDRO 2003 densimeter and an MXD chronology was developed. A correlation analysis was carried out between the MXD chronology and climate variables from the Mohe meteorological station, and the strongest correlation was found with the July–August mean temperature. Therefore, the July–August mean temperature was reconstructed back to 1781 A.D. for the north Greater Khingan Mountains. The reconstruction explained 31.1% of the variance in the instrumental period (1959–2013 A.D.). The dataset includes: (1) the geolocation of the sampling site; (2) tree-ring MXD standard chronology; (3) reconstructed July–August temperature series from 1781 to 2013 in the north Greater Khingan Mountains and 11-year smoothing-average data; (4) statistics of 39 raw tree-ring MXD measurements. The dataset is archived in .shp and .xlsx data formats, and it consists of nine data files with a total size of 27.2 KB (this is compressed to one single file with a size of 24 KB).

Keywords: tree rings; maximum latewood density; North Greater Khingan Mountains; temperature reconstruction

DOI: https://doi.org/10.3974/geodp.2022.03.09

CSTR: https://cstr.escience.org.cn/CSTR:20146.14.2022.03.09

Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2022.04.02.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2022.04.02.V1.

Received: 25-3-2022; **Accepted:** 11-7-2022; **Published:** 25-9-2022

Foundation: Ministry of Science and Technology of P. R. China (2017YFA0603302)

***Corresponding Author:** Li, M. Q. GLU-2022-9912, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science, limq@igsnrr.ac.cn

Data Citation: [1] Li, M. Q., Lan, Y. A July–August mean-temperature dataset reconstructed based on the maximum latewood density of hailar pine in the North Greater Khingan Mountains (1781–2013) [J]. *Journal of Global Change Data & Discovery*, 2022, 6(3): 395–401. https://doi.org/10.3974/geodp.2022.03.09. https://cstr.escience.org.cn/CSTR:20146.14.2022.03.09.

[2] Li, M. Q., Lan, Y. Reconstruction dataset of yearly July-August mean temperature from tree-ring maximum latewood density of *Pinus sylvestris* var. *mongolica* at North Greater Khingan Mountains (1781–2013) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2022. https://doi.org/10.3974/geodb.2022.04.02.V1. https://cstr.escience.org.cn/CSTR:20146.11.2022. 04.02.V1.

1 Introduction

Tree-ring is an important proxy for studying paleoclimate due to its accurate dating, high resolution, wide distribution, and good replication[1]. It is playing an important role in reconstructing temperature[2], precipitation, and dry/wet variations[3–5] on centennial to millennial timescales. Among the tree-ring data used for climate reconstruction, the maximum latewood density (MXD) is a well-known proxy for summer or early-fall temperatures[6–9]. Northeast China is one of the three major forest areas in China, and it has an area of more than 30 million hectares[10]. In addition, it is a major agricultural region, and its production of grain was 20.26% of the national total in 2018[11]. Temperature is an important factor affecting agriculture and forest production. Therefore, studying historical temperature variations and exploring the regular pattern of climate change in Northeast China is of great significance for guiding agricultural and forestry production.

MXD data have been used for studying temperature variations in the Greater Khingan Mountains[12]. However, there have been few MXD-based reconstructions, and the reconstruction span in our study area is currently less than 200 years. The purpose of this study was thus to reconstruct a 233-year temperature record based on MXD standard chronology from *Pinus sylvestris* var. *mongolica* in the north Greater Khingan Mountains, Northeast China (Figure 1 and Table 1). This will provide basic data for predicting future climate-change scenarios and for guiding agriculture and forest production.

Table 1 Location of sampling site

Location	Longitude	Latitude	Altitude
Huzhong National Nature Reserve, Heilongjiang province	123.08°E	51.79°N	950 m

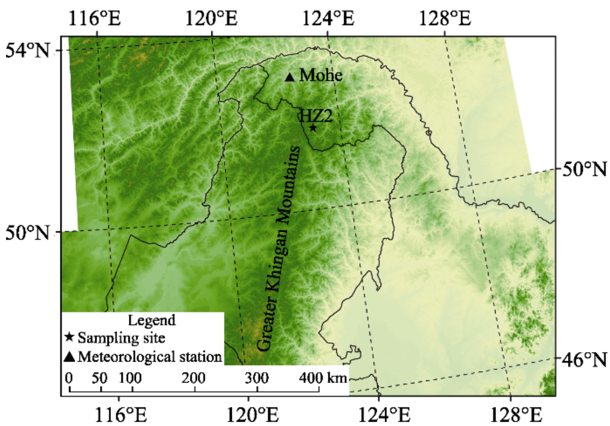

Figure 1 Map showing the locations of the sampling site and the meteorological station

2 Metadata of the Dataset

The metadata of the Reconstruction dataset of yearly July-August mean temperature from tree-ring maximum latewood density of *Pinus sylvestris* var. *mongolica* at North Greater Khingan Mountains (1781–2013) is summarized in Table 2[13]. It includes the dataset full name, short name, authors, year of the dataset, temporal resolution, data format, data size, data files, data publisher, and data sharing policy, etc.

3 Methods

3.1 The MXD Chronology Development and Temperature Reconstruction

The MXD standard chronology was developed using the ARSTAN software package. Each MXD series of tree-ring measurements was fitted with an 80 cubic smoothing spline to remove the non-climatic trends[15]. Each detrended index series was calculated as the ratio of the tree-ring value to the corresponding spline curve value of a given year, by which the densitometry series were transformed to dimensionless time series. All index series of tree-ring data from the site were then averaged to form a mean MXD chronology using a bi-weight robust mean value function[16].

To investigate the tree-growth–climate relationship, we calculated Pearson's correlation coefficients between the MXD standard chronology (x) and climatic variables (y) (monthly mean temperature and monthly precipitation) from the Mohe meteorological station during the instrumental period of 1959–2013. The results indicated that the July–August mean temperature is the major factor limiting tree growth. The correlation coefficients (r) were calculated using the equation:

$$r = \frac{1}{n}\sum_{n}^{i=1}\left(\frac{x_i - \overline{x}}{\delta_1}\right)\left(\frac{y_i - \overline{y}}{\delta_2}\right) \tag{1}$$

where δ is the standard error.

Based on the tree-growth–climate relationship, a linear regression produced a transfer function between the MXD standard chronology (MXD) and the July–August mean temperature ($T_{\text{mean7–8}}$). We then reconstructed the regional temperature series. The following equation was used for this calculation:

$$T_{\text{mean7–8}} = a\text{MXD} + b \tag{2}$$

where a and b are constants.

3.2 Data Collection and Processing

We collected 61 tree-ring cores from 28 *Pinus sylvestris* var. *mongolica* trees at the study site (51.79°N, 123.08°E, 950 m a.s.l.) in Huzhong National Nature Reserve from the north Greater Khingan Mountains in September 2013. In the tree-ring laboratory of the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, all cores were carefully cross-dated after air drying and sanding; we selected 39 tree-ring cores from 22 trees for temperature reconstruction. The tree-ring widths were measured using LinTab, and the tree-ring density data were measured using a DENDRO 2003 densimeter. We then developed the MXD chronology based on this tree-ring density data. In addition, we also collected the instrumental data from the Mohe meteorological station[1] and analyzed the correlations between these data and the MXD chronology to find the major limiting factor for MXD in *Pinus sylvestris* var. *mongolica*. Based on the tree-growth–climate relationship, we reconstructed the past temperature series in our study area. A flowchart for this process is shown in Figure 2.

4 Data Results and Validation

4.1 Data Composition

The dataset comprises the following parts: (1) the geolocation of the sampling site; (2) statistics

[1] https://data.cma.cn/.

Table 2 Metadata summary of the Reconstruction dataset of yearly July-August mean temperature from tree-ring maximum latewood density of *Pinus sylvestris* var. *mongolica* at North Greater Khingan Mountains (1781–2013)

Items	Description
Dataset full name	Reconstruction dataset of yearly July-August mean temperature from tree-ring maximum latewood density of *Pinus sylvestris* var. *mongolica* at North Greater Khingan Mountains (1781–2013)
Dataset short name	NGKM_MXD_Tem0708_1781-2013
Authors	Li, M. Q. GLU-2022-9912, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, limq@igsnrr.ac.cn Lan, Y., Guangdong Meteorological Observatory, chinalanyu12@163.com
Geographical region	North Greater Khingan Mountains, China
Year	1781–2013
Temporal resolution	Year
Data format	.shp, .xlsx
Data size	27.2 KB
Data files	(1) geolocation of the sampling site; (2) tree-ring MXD standard chronology; (3) reconstructed July–August temperatures from 1781 to 2013 in the North Greater Khingan Mountains and 11-year smoothing-average data; (4) statistics of 39 raw tree-ring MXD measurements
Foundation	Ministry of Science and Technology of P.R.China (2017YFA0603302)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[14]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

of 39 raw tree-ring MXD measurements (Table 3); (3) tree-ring MXD standard chronology (Figure 3); (4) reconstructed July–August temperature from 1781 to 2013 in North Greater Khingan Mountains and 11-year smoothing-average data (Figure 4).

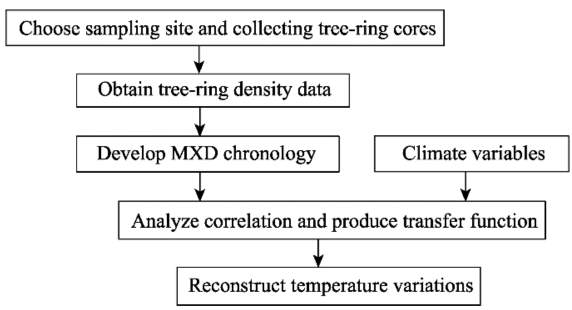

Figure 2 Flow chart showing the procedure that was used to develop the dataset

4.2 Data Products and Validation

The MXD standard chronology covers the period 1722–2013 A.D. (Figure 3). The period 1901–2000 A.D., as common period, was analyzed when we developed the MXD standard chronology. The mean inter-series correlation coefficient is 0.408, the mean correlation coefficients within trees and between trees are 0.560 and 0.406, respectively. The signal-to-noise ratio is 22.09. In addition, the expressed population signal is 0.957. These statistics are similar to those of other tree-ring chronologies in our study area[12], and the results indicate that the chronology can be used for

Table 3 Statistics of 39 raw tree-ring MXD measurements

No.	Core code	Beginning year	Ending year	Span (year)	Average MXD (g/cm^3)	Standard error (g/cm^3)
1	HZ01A	1782	1892	111	8.15	0.96
2	HZ01B	1778	2013	236	6.77	1.49
3	HZ02A	1735	2013	279	5.98	1.40
4	HZ02B	1743	2013	271	7.58	1.29
5	HZ03A	1804	2013	210	8.23	2.13
6	HZ03B	1722	2013	292	5.60	1.27
7	HZ04A	1862	2013	152	9.07	1.78
8	HZ04B	1862	2013	152	7.74	2.59
9	HZ05A	1804	1854	51	9.69	0.97
10	HZ07A	1900	2013	114	9.39	1.13
11	HZ08A	1781	2013	233	6.94	2.10
12	HZ08B	1792	2013	222	6.31	1.40
13	HZ16A	1805	2000	196	7.29	1.50
14	HZ16B	1750	2013	264	7.56	1.75
15	HZ22A	1790	1998	209	7.97	1.40
16	HZ22B	1817	2013	197	7.65	1.44
17	HZ23B	1855	2005	151	8.70	1.40
18	HZ24A	1837	2013	177	7.27	1.64
19	HZ24B	1847	2013	167	6.90	2.10
20	HZ25A	1864	2013	150	7.96	1.28
21	HZ25B	1850	2013	164	7.34	1.12
22	HZ26A	1842	2005	164	7.81	0.89
23	HZ26B	1854	2013	160	7.28	1.15
24	HZ27A	1798	2013	216	6.28	1.53
25	HZ27B	1803	1996	194	6.30	1.37
26	HZ28A	1781	1930	150	5.78	1.43
27	HZ28B	1768	2013	246	5.88	1.97
28	HZ30A	1789	2013	225	7.91	1.22
29	HZ30B	1793	2013	221	7.29	1.36
30	HZ31A	1808	2013	206	7.04	1.81
31	HZ31B	1800	2013	214	6.82	1.52
32	HZ34A	1803	2008	206	8.80	0.90
33	HZ34B	1828	2013	186	8.60	1.16
34	HZ38A	1832	1944	113	9.22	1.19
35	HZ38B	1852	1977	126	8.69	1.40
36	HZ39A	1828	2013	186	8.22	1.37
37	HZ39B	1836	2011	176	7.96	1.56
38	HZ52A	1808	2012	205	7.24	1.62
39	HZ54B	1801	2012	212	7.64	1.40

paleoclimate analysis. The subsample signal strength exceeded 0.85 in 1781 with seven cores. Therefore, we considered 1781 as the beginning year for reconstruction.

Based on the relationships between the MXD chronology and climate variables, we reconstructed the July–August mean temperature during the period 1781–2013 A.D. in the north Greater Khingan mountains (Figure 4). The transfer function is $T_{mean7–8}$ = 3.46MXD + 13.5, and the model explained 31.1% of the variance in July–August mean temperature with good "leave-one-out" cross-validation results during the instrumental period 1959–2013. The sign test result was statistically significant at the 0.01 level for the original data. The value of the reduction of error (RE) and product mean *t*-test results were found to be high, suggesting good estimation ability, with the correlation as 0.52 ($n = 55$, $p < 0.01$). Split-period validations were also conducted. The calibration periods were set to be 1959–1988 and 1984–2013, and the validation periods were 1989–2013 and 1959–1983, respectively. The results showed that RE (0.279 and 0.319) and the coefficient of error (0.278 and 0.315) were above zero, although the sign-test result was just statistically significant at the 0.01 level for the original data for the calibration period 1959–1988. Furthermore, the correlation coefficients between the reconstructed series and the instrumental data were 0.59 and 0.58 for the validation periods 1989–2013 and 1959–1983. The validation results suggest that the model is relatively robust with sufficient skills of estimation, and the MXD standard chronology can thus be used for regional climate reconstruction.

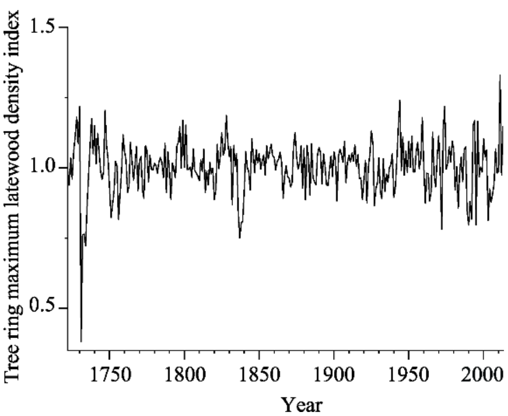

Figure 3 the tree-ring maximum latewood density chronology

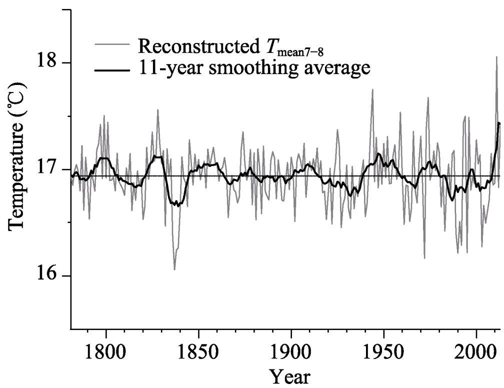

Figure 4 Reconstructed July–August mean temperatures and 11-year smoothing average from the Huzhong National Nature Reserve

5 Discussion and Conclusion

In this study, we obtained tree-ring density data and developed an MXD chronology based on incremental cores collected from *Pinus sylvestris* var. *mongolica* on the Huzhong National Nature Reserve in the north Greater Khingan Mountains, Northeast China. Based on the relationship between the MXD chronology and climate variables, we reconstructed the July–August mean temperature for a period of 233 years in our study area, covering 1781–2013 A.D. with a temporal resolution of one year. This study increases the number and spatial distribution of climate-reconstruction sites. It also provides base data for understanding past climate change, exploring the regular pattern of climate change, and predicting future climate-change scenarios.

Author Contributions

Li, M. Q. designed the algorithms for the dataset. Li, M. Q. and Lan, Y. contributed to the data processing and analysis. Li, M. Q. wrote the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Fritts, H. C. Tree Rings and Climate [M]. London: Academic Press, 1976.

[2] Liang, E. Y., Shao, X. M., Qin, N. S. Tree-ring based summer temperature reconstruction for the source region of the Yangtze River on the Tibetan Plateau [J]. *Global and Planetary Change*, 2008, 61(3/4): 313–320.

[3] Shao, X. M., Huang, L., Liu, H. B., *et al.* Reconstruction of precipitation variation from tree rings in recent 1000 years in Delingha, Qinghai [J]. *Science in China Series D-Earth Sciences*, 2005, 48(7): 939–949.

[4] Cook, E. R., Anchukaitis, K. J., Buckley, B. M., *et al.* Asian Monsoon Failure and megadrought during the last millennium [J]. *Science*, 2010, 328(5977): 486–489.

[5] Yu, J., Shah, S., Zhou, G., *et al.* Tree-ring-recorded drought variability in the Northern Daxing'anling Mountains of Northeastern China [J]. *Forests*, 2018, 9(11): 674. DOI: 10.3390/f9110674.

[6] Hughes, M. K., Schweingruber, F. H., Cartwright, D., *et al*. July-August temperature at edinburgh between 1721 and 1975 from tree-ring density and width data [J]. *Nature*, 1984, 308(5957): 341–344.

[7] Jacoby, G. C., Ivanciu, I. S., Ulan, L. D. A 263-year record of summer temperature for Northern Quebec reconstructed from tree-ring data and evidence of a major climatic shift in the early 1800s [J]. *Palaeogeography Palaeoclimatology Palaeoecology*, 1988, 64(1/2): 69–78.

[8] Briffa, K. R., Jones, P. D., Bartholin, T. S., *et al*. Fennoscandian summers from AD 500 temperature changes on short and long timescales [J]. *Climate Dynamics*, 1992, 7: 111–119.

[9] Li, M., Huang, L., Yin, Z. Y., *et al*. Temperature reconstruction and volcanic eruption signal from tree-ring width and maximum latewood density over the past 304 years in the southeastern Tibetan Plateau [J]. *International Journal of Biometeorology*, 2017, 61(11): 2021–2032.

[10] Bai, W., Wang, Z. On Sustainable forest management in forest areas of Northeast China [J]. *Forest Resources Management*, 2008(6): 1–7.

[11] Tang, L., Wu, D., Miao, W., *et al*. Sustainable development of food security in Northeast China [J]. *Engineering Sciences*, 2019, 21(5): 19–27.

[12] Sun, Y., Wang, L. L., Chen, J., *et al*. Reconstructing mean maximum temperatures of May-August from tree-ring maximum density in North Da Hinggan Mountains, China [J]. *Chinese Science Bulletin*, 2012, 57(16): 2007–2014.

[13] Li, M. Q., Lan, Y. Reconstruction dataset of yearly July-August mean temperature from tree-ring maximum latewood density of *Pinus sylvestris* var. *mongolica* at North Greater Khingan Mountains (1781–2013) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2022. https://doi.org/10.3974/geodb.2022.04.02.V1. https://cstr.escience.org.cn/CSTR:20146.11.2022.04.02.V1.

[14] GCdataPR Editorial Office. GCdataPR data sharing policy [OL]. https://doi.org/10.3974/dp.policy.2014.05 (Updated 2017).

[15] Cook, E. R., Briffa, K. R., Meko, D. M., *et al*. The segment length curse in long tree-ring chronology development for paleoclimatic studies [J]. *Holocene*, 1995, 5(2): 229–237.

[16] Cook, E. R. A time series analysis approach to tree ring standardization [D]. Tucson: The University of Arizona, 1985.